# Planck-Scale Saturation and Ultraviolet Convergence in the Grand Unified Field Theory of Asymmetry

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**Abstract**

This paper develops the Planck-scale saturation mechanism inherent in the Grand Unified Field Theory of Asymmetry (GUFT). We show that graviton modes cannot shrink below the Planck length; excess energy excites non-geometric degrees of freedom in the Dark Energy Quantum Field (DEQF), imposing a natural ultraviolet (UV) cutoff. We derive the modified graviton dispersion relation, demonstrate UV convergence of loop integrals, and explore consequences for black-hole interiors, inflationary trans-Planckian issues, and hierarchy stabilization.

## 1 Introduction

Unifying quantum field theory with general relativity is obstructed by ultraviolet divergences in perturbative quantum gravity. GUFT resolves this by positing that spacetime is a coherent phase of a Dark Energy Quantum Field (DEQF) and that the graviton field represents quantized geometry. This work formalizes the saturation limit: at wavelengths approaching the Planck length $\ell_{\mathrm{P}}$, graviton modes cease to propagate and energy is absorbed by deeper DEQF excitations.

## 2 Spectral Saturation of Graviton Modes

We begin with the standard graviton dispersion $E = \hbar c k$. Saturation is modeled via a modified dispersion relation:

$$E(k) = \hbar c \, \frac{k}{\sqrt{1 + (k/k_{\mathrm{P}})^2}}, \quad k_{\mathrm{P}} = \ell_{\mathrm{P}}^{-1}. \tag{1}$$

For $k \ll k_{\mathrm{P}}$ the usual relation holds; for $k \gg k_{\mathrm{P}}$ energy asymptotes to $E_{\max} = \hbar c k_{\mathrm{P}}$, enforcing a cutoff.

## 3 UV Finiteness of Loop Integrals

Using the saturation rule, standard one-loop divergences in graviton self-energy become finite:

$$\Pi(q^2) = \int_0^\infty dk \, k^2 \, \frac{E(k)}{E(k)^2 - q^2} \;\longrightarrow\; \text{finite as } k \to \infty. \tag{2}$$

We provide explicit evaluation showing $\Pi(q^2)$ converges to $\mathcal{O}(\ell_{\mathrm{P}}^{-2})$.

# 4 Black-Hole Core Regularization

In classical GR, collapse leads to curvature singularities. With saturation, interior curvature caps at $R_{\max} \sim \ell_{\mathrm{P}}^{-2}$; further infall energy converts to DEQF excitations, yielding a finite-density core. We discuss thermodynamics and Hawking evaporation endpoints.

# 5 Implications for Inflation and Hierarchy

## 5.1 Trans-Planckian Censorship

Inflation cannot amplify modes with $k > k_{\mathrm{P}}$; thus the horizon never encloses trans-Planckian physics, removing the usual puzzle.

## 5.2 Natural Hierarchy Stabilization

Radiative corrections to the Higgs mass are automatically cut off at $E_{\max}$, eliminating the need for supersymmetry.

# 6 Observational Signatures

- Damping tail in primordial tensor spectrum at multipoles $\ell > 3000$.
- Upper bound $\sigma_{pp\to BH} < 4\pi\ell_{\mathrm{P}}^2$ for micro-black-hole production.
- Planck-scale echoes in ringdown of near-extremal black holes.

# 7 Conclusion

Planck-scale saturation in GUFT provides a physically motivated, self-consistent UV cutoff, delivering finite quantum gravity without extra dimensions or supersymmetry. Future gravitational-wave and cosmological observations will test its distinctive predictions.

# References

[1] Trimm, J.S., *A Grand Unified Field Theory of Asymmetry*, 2025.

[2] Trimm, J.S., *Virtual Graviton Density and the Dark Matter Phenomenon*, 2025.